AEROSPACE REPORT NO.
ATR-74(7334)-1. VOL. IV
PART 3

Space Shuttle/Payload Interface Analysis (Study 2.4) Final Report

Volume IV

Business Risk and Value of Operations in Space (BRAVO)

Part 3 - Workbook

D82A

Prepared by
ADVANCED VEHICLE SYSTEMS DIRECTORATE
Systems Planning Division

15 February 1974

Prepared for OFFICE OF MANNED SPACE FLIGHT
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D. C.

Contract No. NASW-2472

Systems Engineering Operations
THE AEROSPACE CORPORATION

Aerospace Report No.
ATR-74(7334)-1, Vol. IV
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FOREWORD

The Space Shuttle/Payload Interface Analysis (Study 2.4) Final Report is comprised of five volumes, which are titled as follows:

Volume I - Executive Summary

Volume II - Space Shuttle Traffic Analysis

Volume III - New Expendable Vehicle with Resuable Solid Rocket Motors

Volume IV - Business Risk and Value of Operations In Space (BRAVO)

- Part 1 - Summary
- Part 2 - User's Manual
- Part 3 - Workbook
- Part 4 - Computer Programs and Data Look-Up

Volume V - Payload Community Analysis

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1. INTRODUCTION

The BRAVO Workbook is a collection of blank worksheets for use on each BRAVO problem to be analyzed. Worksheets are being supplied for recording the inputs for the BRAVO analysis, working out the definition of mission equipment, recording inputs to the satellite synthesis computer program, estimating satellite earth station costs, costing terrestrial systems, and cost-effectiveness calculations.

The group of analysts working BRAVO will normally use up a set of worksheets on each problem. If more worksheet blanks are required than supplied, the Workbook pages are of sufficiently good quality that the user can duplicate them.

2. WORKBOOK FORMS FOR INPUTS TO THE ANALYSIS

BRAVO CHECK LIST
INPUT AND PROBLEM DEFINITION

Information[1] to be covered in discussion with potential user(s) to be completed in defining each BRAVO problem. The resulting information is then the input to a BRAVO analysis.

1. SATELLITE SYSTEM OBJECTIVE
   - (a) Purpose, Function Performed
   - (b) Product or Service Rendered
2. SATELLITE MISSION EQUIPMENT
   - (a) Type
   - (b) Description
     - (1) Components List
     - (2) Component Performance
     - (3) Component Failure Rates
     - (4) Component Wear Out
     - (5) Maximum Capacity (Each Set of Mission Equipment)
     - (6) Number of Sets Required On Orbit[1]
     - (7) Location
     - (8) Spacecraft Interfaces (Power Required, Pointing Accuracy)
     - (9) Ground Terminal Interfaces (Ground Link, Data Handling and Transmission)

---

(1) Usually changes from one time period to the next.

BRAVO CHECK LIST

INPUT AND PROBLEM DEFINITION (CONT'D)

OR

2. (ALTERNATIVE)[1] INFORMATION SENSED OR TRANSMITTED BY THE SATELLITE

   (a) Type (Visual, IR, Voice, Digital, T.V., etc.)

   (b) Source(s) and Coverage

   (c) Peak Rates (e.g., Number of Channels, Number of Images per Day)

   (d) Duty Cycle

   (e) Tolerances and Quality

   (f) Elapsed Time for Transmission (e.g., Real Time)

   (g) Electromagnetic Regime(s)

3. SATELLITE INTERFACES WITH EARTH SURFACE

   (a) Geographic Locations

   (b) Descriptions

   (c) Ground Link Relay

4. TIME (YEAR) REQUIRED, GROWTH

   (a) Initial Operation

---

(1) Can be used when BRAVO capability includes defining and synthesizing the mission equipment (e.g., communication links through satellite transducers, multiuser earth observations).

(b) Full Operation

(c) Growth Rate(s)

5. PREFERRED SPACE SYSTEM APPROACH

(a) Satellite Altitude and Inclination

(b) Satellite Features (Automated and Ground-Controlled Features)

(c) Outage Allowance

(d) Dedicated or Shared System

6. COMPETING TERRESTRIAL SYSTEMS

(a) Type of Terrestrial System

(b) Designation

(c) Outage Allowance

7. SYSTEM BUDGET[1]

(a) Buy-In Cost (Goal)

(b) Peak Annual Funding (Goal)

8. SPECIAL PROBLEMS

(a) Advanced State-of-the-Art Required

(1) Advanced Technology

(2) Advanced Operating Mode

---

(1) Since the normal analysis compares space systems and ground systems, this information is not normally required. The information would be helpful in guiding the analysis, however. If there is not a competing ground system, these data are needed.

(b) Non-Standard STS Requirements

9. REFERENCES

(a) Related Space System References

(b) Related Terrestrial System References

3. WORKBOOK FORMS FOR COMMUNICATIONS MISSION EQUIPMENT DEFINITION CALCULATIONS

GEOMETRY

101	Subtended angle (from satellite), α'	_____	°
102 a	Elevation angle, transmitting station (E_1)	_____	°
b	Elevation angle, receiving station (E_2)	_____	°

SATELLITE ANTENNA

201	Subtended angle from line 101	_____	°
202	Antenna pointing error	_____	°
203	Antenna beamwidth. Add lines 201 and 202	_____	°
204 a	Tentative highest frequency gain G.	_____	
b	Tentative highest frequency gain GdB	_____	dB
205 a	Highest frequency	_____	Hz
b	Lowest frequency	_____	Hz
206	Antenna Diameter	_____	M
207	Preliminary low frequency gain	_____	dB
208 a	Uplink frequency	_____	Hz
b	Downlink frequency	_____	Hz
209	Preliminary uplink gain _____ dB		
210	Uplink multiple beam factor _____ dB		
211	Uplink antenna on axis gain. Line 209 minus line 210	_____	dB
212	Preliminary downlink gain _____ dB		
213	Downlink multiple beam factor _____ dB		
214	Downlink antenna on axis gain. Line 212 minus line 213	_____	dB
215	Number of transponders	_____	

PRELIMINARY ESTIMATE. EARTH STATION TRANSMISSIONS

251		-180	dBW
252	Satellite receiving antenna gain from line 211	-	dB
253	20 log F_U		dB
254	Bandwidth (B)		dB
255	Atmospheric and rain attenuation		dB
256	Uplink carrier to noise ratio $(C/N)_U$		dB
257	$P_T + G_T$ Sum lines 251 through 256		dBW
258	Earth station antenna gain (G_T)		dB
259	Earth Station transmitter power (P_T) . . . . . line 257 minus 258		dBW
260	Earth Station transmitter power (P_W)		Watts

UPLINK

301	Earth transmitter power		dBW
302	Earth transmitting antenna gain		dB
303	Sum of line 301 and line 302		dBW
304	Transmitter circuit losses		dB
305	Effective Isotropic Radiated Power (EIRP) line 303 minus line 304 or input data		dBW
306	Free space loss (SL)	dB	
307	Atmospheric and rain attenuation	dB	
308	Pointing loss	dB	
309	Polarization loss	dB	
310	Receiving circuit losses	dB	
311	Total loss. Sum of lines 306 through 310		dB
312	EIRP minus losses. Line 305 minus line 311		dBW
313	On-axis satellite antenna gain (from line 211)	dB	
314	Off-axis loss	3.0 dB	
315	Off-axis gain. Line 313 minus line 314		dB
316	Available carrier power. Line 312 plus line 315		dBW
317	Receiver temperature	^{o}K	
318	Receiver input circuit temperature	^{o}K	
319	Antenna temperature	^{o}K	
320	Effective system noise temperature. Add lines 317 through 319		^{o}K
321	Effective system noise temperature	dB	
322	Bandwidth (B)	dB	
323		-228.6	
324	System noise power. Add lines 321 through 323		dBW
325	$(C/N)_U$ Line 316 minus line 324		dB

DOWNLINK

401	E_b/N_o Required			dB
402	Margin required			dB
403	C/N Line 401 plus line 402			dB
404	$(C/N)_D$			dB
405		-228.6		
406	G/T	- ____	dB/°K	
407	B	____	dB	
408	Add lines 405 through 407			dBW
409	Free space loss	____	dB	
410	Atmospheric and rain attenuation	____	dB	
411	Pointing loss	____	dB	
412	Polarization loss	____	dB	
413	Total propagation losses. Add Lines 409 through 412			dB
414	EIRP. Add lines 404, 408 and 413.			dBW
415	Transmitter circuit losses			dB
416	Antenna gain plus transmitter power. Line 414 plus line 415			dBW
417	On-axis satellite antenna gain. From line 214	____	dB	
418	Off-axis loss	3.0	dB	
419	Off-axis gain. Line 417 minus line 418			dB
420	Satellite transmitter power. Line 416 minus line 419			dBW
421	Satellite transmitter power			watts
422	Satellite communications subsystem efficiency			
423	Satellite communications subsystem primary power requirements. Line 421 divided by line 422.			watts

PROCEDURE I - GEOMETRY

1. Number of geographical areas N . . . . . _____
2. Subtended angle α' . . . . . _____ o
3. Elevation angle, transmitting station E_1 . . . . . _____ o
4. Elevation angle, receiving station E_2 . . . . . _____ o
5. Antenna axis off-nadir angle ON_o . . . . . _____ o
6. Antenna axis azimuth AZ_o . . . . . _____ o
7. Uplink beam off-nadir angle ON_1 . . . . . _____ o
8. Uplink beam azimuth AZ_1 . . . . . _____ o
9. Downlink beam off-nadir angle ON_2 . . . . . _____ o
10. Downlink beam azimuth AZ_2 . . . . . _____ o

PROCEDURE 2 -- MULTIPLE BEAM FACTOR

UPLINK

1.	Scan angle - degrees	_____ °
2.	Scan angle - beamwidths	_____
3.	Scan loss	_____ dB
4a.	Number of antenna beams, n	_____
b.	Number of transponders	_____
5.	Blockage diameter ÷ reflector diameter d/D . .	_____
6.	Blockage loss	_____ dB
7.	Uplink multiple beam factor Line 3 plus Line 6	_____ dB

DOWNLINK

21.	Scan angle - degrees	_____ °
22.	Scan angle - beamwidths	_____
23.	Scan loss	_____ dB
24.	Blockage loss from Line 5	_____ dB
25.	Downlink multiple beam factor Line 23 plus Line 24	_____ dB

4. WORKBOOK FORMS FOR SATELLITE EARTH STATION DEFINITION AND COST ESTIMATING

Worksheet, Satellite Communication System Tradeoff Analysis

System Designation _____

No. of Earth Stations _____

Location (Area) of Earth Stations _____

No. of Satellites _____

For other inputs, see Section 4. B. 1. of Volume IV, Part 2, User's Manual

Earth Station G/T, dB/^{o}K						
Earth Station Unit Investment Cost[1]						
Satellite Weight[2]						
Satellite Unit Investment Cost in Orbit[3]						
System Investment Cost[4]						
Earth Stations						
Satellites						
Total						

(1) Calculations, Section 4. D. 2. c (page 4-88) of Volume IV, Part 2, User's Manual
(2) Calculations, Section 4. D. 2. c (page 4-88) of Volume IV, Part 2, User's Manual
(3) Calculations, Section 4. D. 2. c (page 4-88) of Volume IV, Part 2, User's Manual
(4) Unit costs of earth stations and satellites times quantities of each.

Worksheet, Satellite Earth Station Costs

INPUTS:

	Frequency Downlink	_____ GHz
	Number of Channels	_____
	Receiving System Figure of Merit, G/T	_____ $dB/^{o}K$
	Number of Antenna Systems, N_a	_____
	Year Construction Completed	_____

CALCULATIONS:

1. Antenna Gain, G = G/T + T = (_____)$dB/^{o}K$ + (_____)$dB^{o}K$ = (_____)dB

INVESTMENT COST

2. Antenna System Cost, A, From Figure 4-21*
3. Receiving Preamplifier Cost (R)
4. Sum, Lines 2 + 3
5. No. Antenna System (N_a) times Line 4
6. Power, Monitor, and Test (PMT) from Figure 4-22 *
7. ($N_a^{0.5}$) times Line 6
8. Sum, Lines 5 + 7
9. Mgmt., Integr., and Test, [(MIT)-1] = Line 8 x 33%
10. Site and Building Costs (SB) from Figure 4-23*
11. Sum, Lines 8 + 9 + 10
12. Miscellaneous Costs, [(Mscl)-1] = Line 11 x 33%
13. Multiplex Modulation & Trans. (MMT) from Figure 4-24 *
14. Sum, Lines 11 + 12 + 13
15. Const. Area Cost Factor (F_c) from Table 4-9*
16. Yr. Const. Completed Minus 1973 (n)
17. Calculate: $1 / (1.08)^n$
18. Total Investment Cost, Lines 14 x 15 x 17

ANNUAL OPERATING COST

19. Cost per Year = (0.126) x (Line 18)

* From Volume IV, Part 2, User's Manual

Worksheet, Satellite Earth Station Cost Summary

Years →

Earth Station Designation	Investment Or Operations												

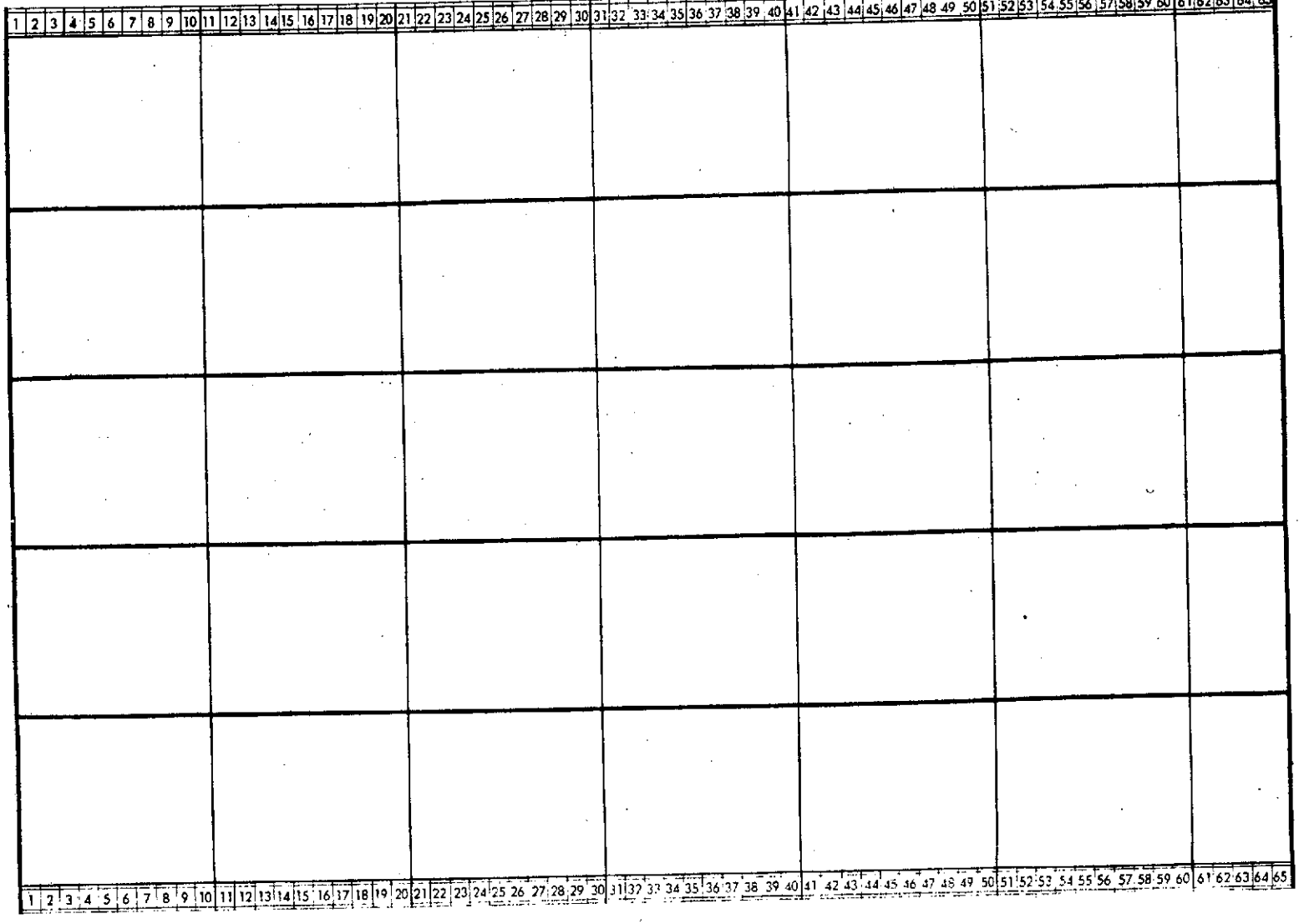
5. WORKBOOK FORMS FOR SATELLITE SYNTHESIS PROGRAM INPUT SHEETS

Satellite Synthesis Computer Program Input Sheets

65 COLUMN KEYPUNCH FORM – 1

FF

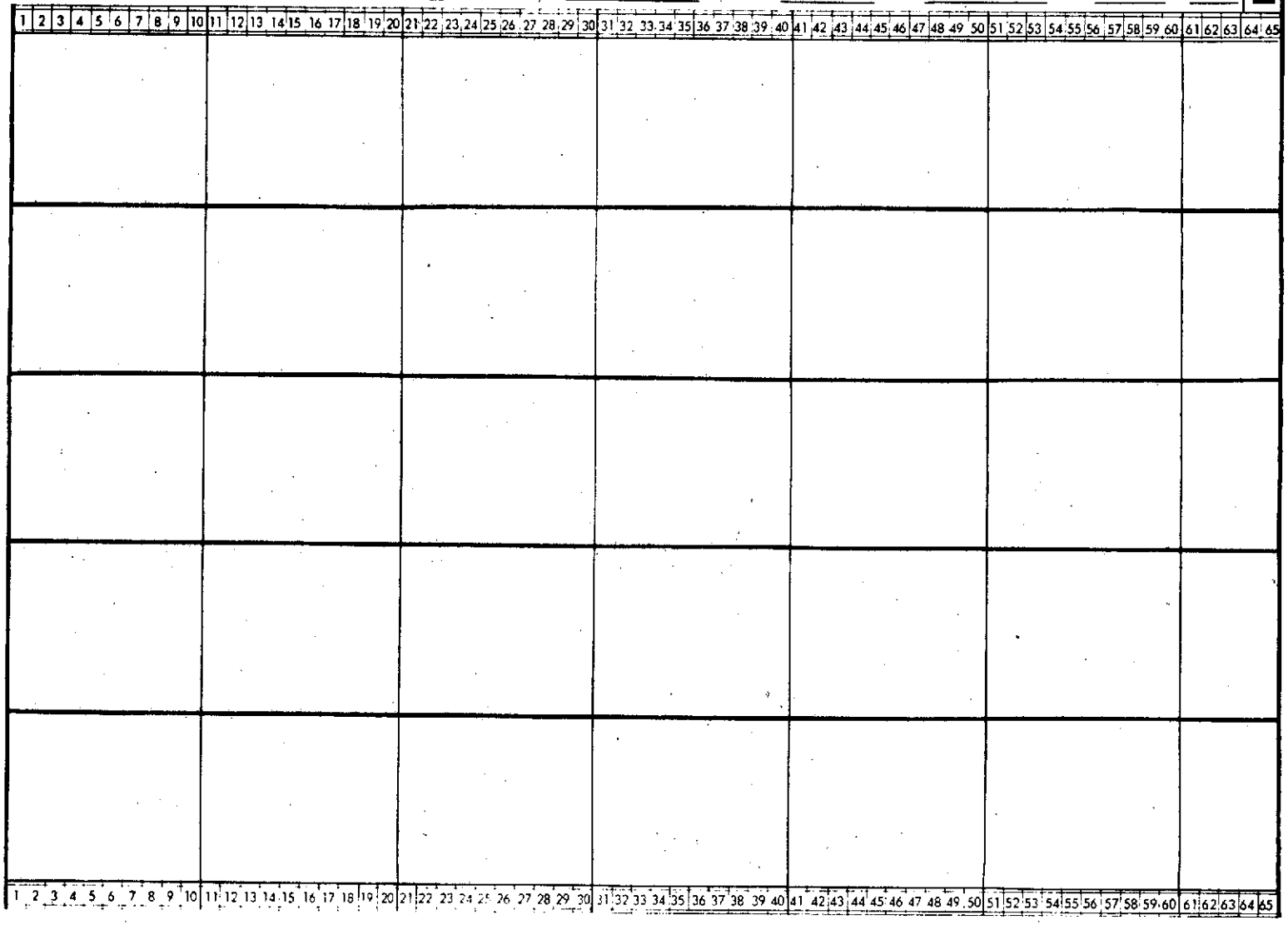
PROGRAMMER _____ KEYPUNCHED _____ VERIFIED _____ DATE _____ PAGE _____ OF _____



Satellite Synthesis Computer Program Input Sheets

65 COLUMN KEYPUNCH FORM – 1

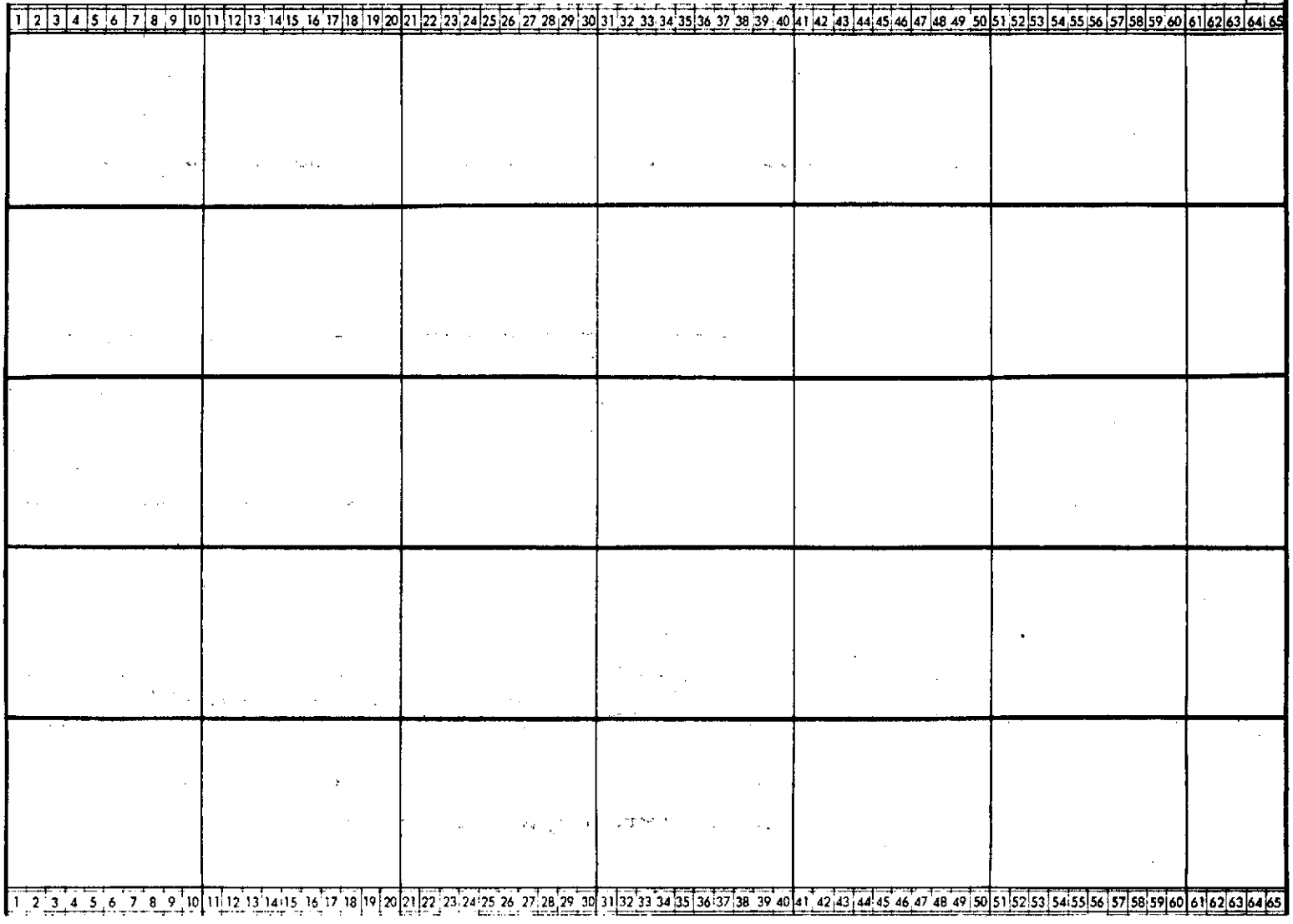
PROGRAMMER _____ KEYPUNCHED _____ VERIFIED _____ DATE _____ PAGE _____ OF _____ FF



Satellite Synthesis Computer Program Input Sheets

65 COLUMN KEYPUNCH FORM - 1

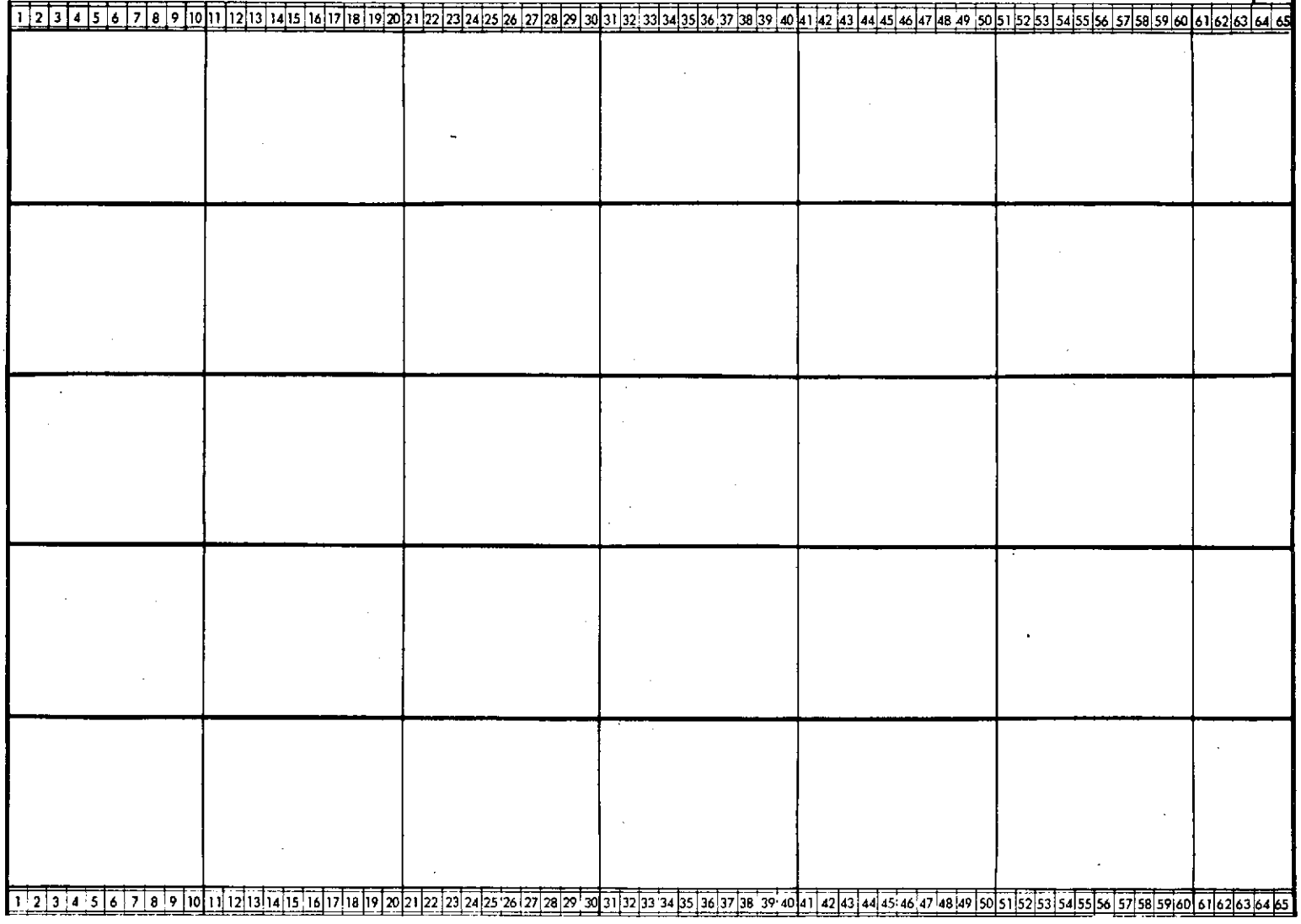
PROGRAMMER _____ KEYPUNCHED _____ VERIFIED _____ DATE _____ PAGE _____ OF _____ FF



Satellite Synthesis Computer Program Input Sheets

65 COLUMN KEYPUNCH FORM – 1

PROGRAMMER _____ KEYPUNCHED _____ VERIFIED _____ DATE _____ PAGE _____ OF _____ FF



6. WORKBOOK FORMS FOR SATELLITE TRANSPORTATION ACCOMMODATION AND TRAFFIC ANALYSIS

Satellite Transportation Accommodation And Traffic Analysis

1. INPUTS, PROGRAM DEFINITION
   - (a) Destination: _____
   - (b) Number of Satellites On Orbit: _____
   - (c) Initial Installation Schedule: _____
   - (d) Mission Equipment & Spacecraft Model Change Schedule: _____
   - (e) Satellite Design Inputs: _____
     - (1) Weight: _____
     - (2) Dimensions: _____
     - (3) MMD: _____
     - (4) Satellite and Launch Vehicle Reliability Parameters: _____
     - (5) Other Weights Chargeable to Satellite: _____
     - (6) _____
2. SITE SELECTION: _____
3. CHARACTERISTIC VELOCITY: _____

Satellite Transportation Accommodation And
Traffic Analysis (Cont'd)

4. VELOCITY REQUIRED ABOVE 160 NMI (ΔV_c):

Satellite Transportation Accommodation And
Traffic Analysis (Cont'd)

5. LAUNCH VEHICLE/PAYLOAD ACCOMMODATION ANALYSIS:

Satellite Transportation Accommodation And
Traffic Analysis (Cont'd)

6. TRAFFIC ANALYSIS:

Satellite Schedule and Traffic Form

SATELLITE NAME: _____ CODE NO. _____

ORBIT: _____ LAUNCH SITE: _____

Satellite Type Weight, Length, Diam.	Event	Schedule (Year)
	Up Flight	
	Down Flight	
	Revisit	
	M/E(1) Modification	
	S/C(2) Modification	
	Up Flight	
	Down Flight	
	Revisit	
	M/E(1) Modification	
	S/C(2) Modification	
	Up Flight	
	Down Flight	
	Revisit	
	M/E(1) Modification	
	S/C(2) Modification	

(1) Mission Equipment (2) Spacecraft

7. WORKBOOK FORMS FOR SATELLITE SYSTEM COST ESTIMATE

BRAVO Worksheet - Satellite Cost Estimate
Basic Input Information

Input Variable	Input Value(1)	Input Description	Remarks
NAME ←		Title	Name for Identification
TYPE ←		Satellite Type	Current design for reuse, low-cost design
WS←		Structure Weight	Reference expendable weights by subsystem. If satellite is current design reusable (CDR), subsystem weights for reusable design must also be entered (lbs).
WE ← WER ←(2)		Electrical Power Weight	
WC ←(2) WCR ←		Communications Weight	
WA ←(2) WAR ←		Stability & Control Dry Weight	
WAP ←(2) WAPR ←		Stability & Control Propellant Weight	
WP ←		Propulsion Inerts Dry Weight	
WPP ←		Propulsion Propellants Weight	
WM ←(2) WMR ←		Mission Equipment Weight	
M2 ←		Mission Equipment Type	Communication, Earth Resources, etc.
E1 ←		Init. Elec. Power	Watts

(1) For definition of numerical code see section 3 a-j in Volume IV, Part 2, User's Manual.

(2) Input variable for CDR-type satellite.

BRAVO Worksheet - Satellite Cost Estimate
Basic Input Information (Cont'd)

Input Variable	Input Value(1)	Input Description	Remarks
P2 ←		Propulsion Type	Solid or liquid, if system needed
P1 ←		Propulsion Total Impulse lb/sec	If subsystem needed
C1 ←		Orbit Altitude	Low/synchronous or planetary
LES ←		No. of Satellites In System	No. of satellites required in orbit for system to operate
LCT ←		Design Type (If Low Cost)	If low-cost design is to be considered, the type will be one of three; communications, navigation, or observation
YR ←		Constant Year Dollars	e.g., 1973
LVTYPE ←		Launch Vehicle Type	Shuttle, Shuttle and Tug, or other

(1) For definition of numerical code see section 3 a-j in Volume IV, Part 2, User's Manual.

BRAVO Worksheet - Satellite Cost Estimates
Additional Inputs*

Nominal Input Value	Input Description	Remarks
S1 ← 2	Structure Type	Nominally Exostructure
A1 ← 3	Stability Type	Nominally 3-Axis
FLYP ← 79	First Year of Launch Schedule	Nominally 1979
YRD ← 3	Span of RDT&E	3 (Versus 4 Years or More)
RR ← .39	Refurbish Rate (For Ground Refurbishment)	CDR Nominal is 39 Percent (LCR is 30 Percent)
ALV1 ← (see remarks)	Launch Vehicle Cost	Nominally, if LVTYPE = 1, ALV1 = 10.26 LVTYPE = 2, ALV1 = 11.19

* These inputs are automatically set at nominal values, which are used unless overridden by a new input.

BRAVO Worksheet - Satellite Cost Estimate
Schedule Input Information

Item \ FY	Input Variable																				
RDT&E[1] (New or Modified) Spacecraft	SSRS←																				
Mission Equipment	SSRME←																				
SATELLITE LAUNCHES New	SSNEW←																				
Refurb.	SSREF←																				
STS LAUNCHES Shuttle	LVS1←																				
Shuttle + Tug	LVS2←																				
Other[2]	LVS3←																				

(1) Schedules for RDT&E should normally coincide with first year of launch of new or redesigned satellite.

(2) Could be an expendable stage or Shuttle and expendable upper stage combination.

8. WORKBOOK FORMS FOR TERRESTRIAL SYSTEMS DEFINITION AND COSTING

Worksheet, Leased Voice Circuit Costs by Year
1973 Dollars

Link Identification[1]					
Location[2]					
Distance (km)					
Cost/Year/Circuit, 1973[3]					

Annual Costs:

Year	Trend Factor[4]	# Ckts/ Cost[5]	# Ckts/ Cost	# Ckts/ Cost	# Ckts/ Cost	# Ckts/ Cost	Total Cost

(1) Any convenient designation, such as names of terminals.
(2) U. S. Domestic, foreign international, foreign interexchange, or transoceanic.
(3) Depending on location, from Figure 5-1 or Figure 5-2 from Vol. IV, Part 2. Add $1600 for circuit terminal costs if appropriate for comparison with other systems.
(4) Table 5-4, Volume IV, Part 2, User's Manual.
(5) Enter number of circuits in the link in the upper left corner of each box and the cost in the lower right corner. Annual cost equals (cost/year/circuit, 1973) x (trend factor) x $[(\text{number of circuits})^{0.72}]$.

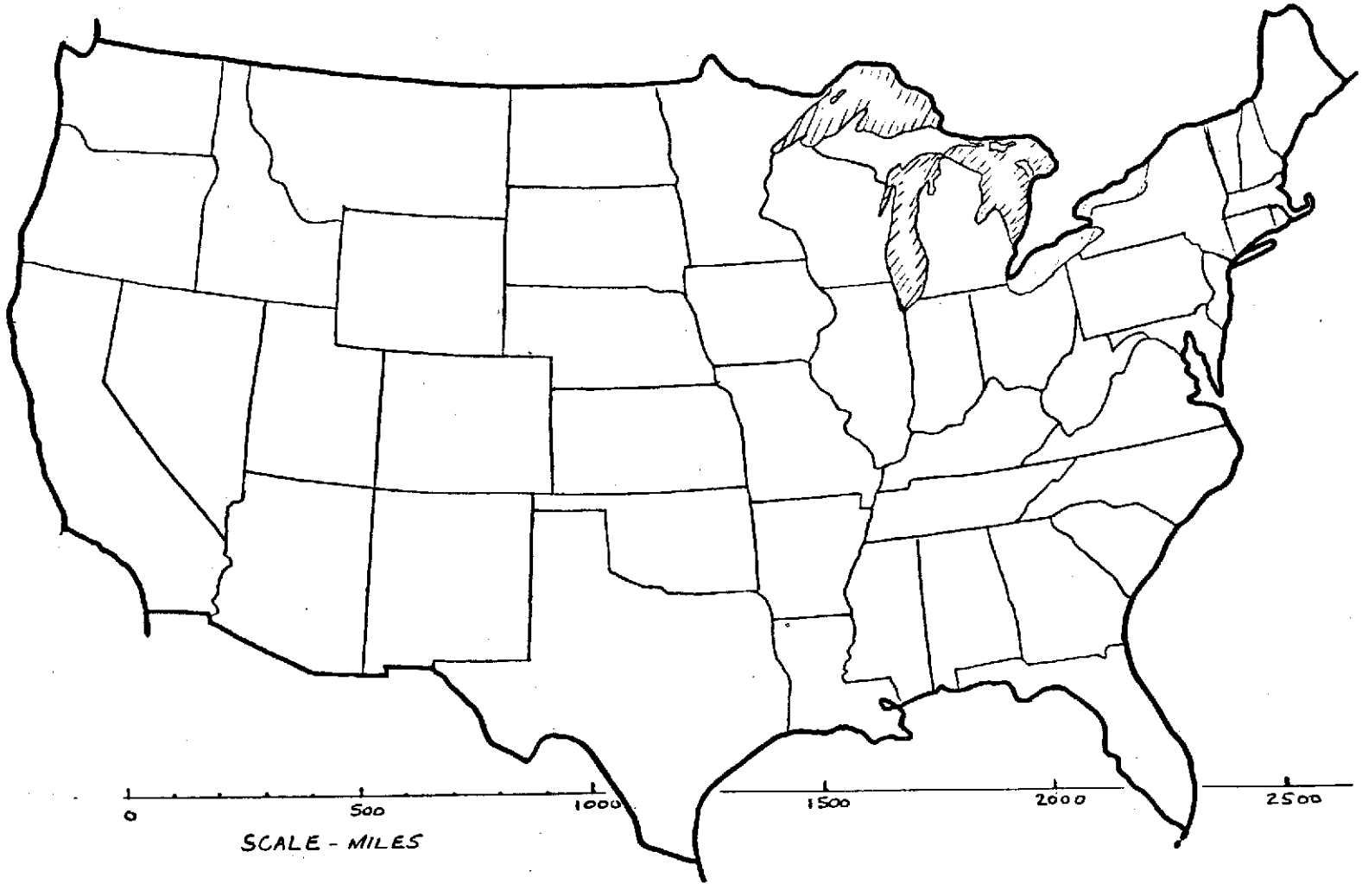
Worksheet, Leased Data Transmission Channels by Year
1973 Dollars

1.	Link Identification(1)						
2.	Location(2)						
3.	Data Rate (kbps)						
4.	Distance (km)						
5.	Cost/Yr/km @ 1609 km, Fig. 5-3*						
6.	Distance Factor Fig 5-4*						
7.	Comm. Line Cost (4x5x6)						
8.	Terminal Cost(3) Fig. 5-5*						
9.	Line & Term. Cost (7+8)						
10.	Location Factor(4)						
Annual Cost(5)							
Year	Trend Factor Table 5-4*						Total Cost

(1) Any convenient designation, such as names of terminals.
(2) Location: U.S. domestic, U.S. transoceanic, foreign interexchange, or foreign international.
(3) One set of terminal equipment is required at each end of a link. Include if terminal costs are included for systems with which this system is compared.
(4) U.S. domestic factor = 1.0; U.S. transoceanic factor = 3.0; foreign interchange factor = 1.8; foreign international factor = 2.9.
(5) Annual cost = (line 7) x (line 10) x (trend factor), or Annual Cost = (line 9) x (line 10) x (trend factor) if terminal costs are included.
* In Volume IV, Part 2, User's Manual.

Worksheet, Leased Communications Costs Summary

	Annual Costs, 1973 Dollars									
Year →										
Voice Circuit Costs (From the Worksheet, Page 8-2)										
Data Chan. Costs (From the Worksheet, Page 8-3)										
Total Lease Costs										



Worksheet - Map for Layout of Terrestrial Microwave Relay Systems in United States

Worksheet, Investment Costs, Line-of-Sight Microwave Relay System

TERMINALS

Year (1)	"n" (2)	Designation (3)	No. Of Chan. Per Term. (4)	Unit Cost (Fig. 5-6)*	Qty. (5)	Constr. Cost Factor (Table 4-9)*	Basic Cost (6)	Incremental Costs For Other Data Rates/Chan.				Total, Basic Cost + Δ	Time Factor $(0.96)^n$ (11)	Total Cost (1973$) (12)
								Data Rate bps (7)	% (8)	F_c (9)	$ Δ (10)			

RELAY STATIONS (13)

Footnotes: See next page.

* In Volume IV, Part 2, User's Manual

Worksheet, Investment Costs, Line-of-Sight Microwave Relay System (Cont'd)

Footnotes:

(1) Year of construction completion.

(2) n = (year of construction completion) - (1973)

(3) Any convenient designation of individual terminals or relay stations, or groups of terminals of the same capacity and construction cost factor, or groups of relays with the same construction cost factor.

(4) Capacity per terminal, number of channels.

(5) Number of terminals or channels being calculated as a group.

(6) Basic cost, assuming standard 4 kHz voice or 4000 bps data channels.

(7) Data rate per channel, in bits-per-second, for non-standard channels. If more than one non-standard data rate, use additional line(s) for calculation.

(8) Ratio, number of non-standard channels of a particular data rate to the total number of channels, expressed as a percent.

(9) F_c = channel capacity cost factor. See the Worksheet on Page 8-8.

(10) Incremental cost due to non-standard channels = (basic cost) x (%) x (F_c).

(11) Time factor to reduce costs four percent per year to reflect trend of technology advances.

(12) Total cost (1973 dollars) = (time factor) x (total basic cost + Δ's) for terminals, or (time factor) x (basic cost) for relay stations.

(13) Column headings for calculating relay station costs are the same as for terminals, except for the 4th and 9th through 13th columns, which are not required in relay station calculations.

Worksheet, Line-of-Sight Microwave Relay Communications System Costs

INVESTMENT[1]

Geographic Area / Year											
Total Investment/Year											
Cumulative Investment											
Less Retirements[2]											
Investment, Operating Stations											
Annual Operations[3]											

(1) From the Worksheet on Page 8-5. Apportion investment costs to year prior to first operation for each terminal or relay. Investment life = 20 years.
(2) Retire investment from 20 years previous (if any).
(3) 14 percent of investment, operating stations, for the preceding year.

Worksheet, Submarine Telephone Cable Communications System Investment Costs
1973 Dollars

Column No. →	1	2	3	4	5	6
Cable Terminal Points	Inputs			Cost Per Half-Circuit per km (Fig. 5-8)*	Length Factor (Fig. 5-9)*	Investment Cost 2x3x4x5
	1st Year In Service	Capacity, No. Half-Circuits	Length (km)			

* In Volume IV, Part 2, User's Manual

Worksheet, Submarine Telephone Cable Communication System Investment Costs By Year, 1973 Dollars

Cable Terminal Points	Investment Or Operating Cost[1]	Year ___	___	___	___	___	___	___	___	___	___	___	___	___	___
Total Investment															
Total Operating															

(1) A 24-year service life should be assumed in calculating replacement times or residual values.

Worksheet, First Class and Air Mail, Annual Costs

INPUTS REQUIRED

For first class and for airmail, enter in tabulation, below:

1. Number of pieces per year for each year
2. Average weight per piece[1]

CALCULATIONS

FIRST CLASS

No. of Pieces (N)
Avg. Wt/Piece (W), oz
Cost = (N) (W) ($0.10)

AIR MAIL

No. of Pieces (N)
Avg. Wt/Piece(W), oz
Cost = (N) (W) ($0.13)

(1) Maximum weights: first class, 12 oz; airmail 8 oz.

Worksheet, Priority Mail, Annual Costs

ALTERNATIVE PROCEDURES:

(a) Enter inputs required in Alternative (a) below:

- Weight/year in 1 to 5-pound packages, for each distance
- Weight/year in packages >5 pounds, for each distance.

(b) Enter inputs required in Alternative (b), next page:

- Weight per piece
- Number of pieces per year to each distance

Alternative (a), Costs for Year _____

Weight Per Piece (lb)	Distance - Miles / Postal Zone	<250 Loc. 1, 2, 3	250-600 4	600-1000 5	1000-1400 6	1400-1850 7	>1850 8	Total
1 - 5 lb	Wt/Year (lb)							
	Cost/Lb	$0.71	$0.73	$0.78	$0.84	$0.90	$0.96	
	Cost/Year*							
More Than 5 lb	Wt/Year (lb)							
	Cost/Lb	$0.50	$0.52	$0.58	$0.66	$0.73	$0.81	
	Cost/Year*							

* Cost/Year = (wt/year in lb) (cost/lb)

Worksheet, Priority Mail, Annual Costs (Cont'd)

ALTERNATIVE PROCEDURES:

(b) Enter inputs required in Alternative (b) below:

- Weight per piece
- Number of pieces per year to each distance.

Alternative (b), Costs for Year _____

Weight Per Piece (lb)	Distance - Miles / Postal Zone	250	250-600	600-1000	1000-1400	1400-1850	1850	Total
		Loc. 1, 2, 3	4	5	6	7	8	
	No. Pieces/Year Cost/Piece* Cost/Year**							
	No. Pieces/Year Cost/Piece Cost/Year							
	No. Pieces/Year Cost/Piece Cost/Year							
	No. Pieces/Year Cost/Piece Cost/Year							
	No. Pieces/Year Cost/Piece Cost/Year							
							Total Cost/Year	

* From Table 5-11 in Volume IV, Part 2, User's Manual.

** Cost/Year = (No. pieces/year) (cost/piece)

Worksheet, Second Class Mail, Annual Cost

INPUTS REQUIRED

- Classification[1]. Line out the two columns of rates not used
- Total weight of publications/year by distance or postal zone
- No. of pieces/year, enter in table
- No. pounds reading matter/year, enter in table

CALCULATIONS

	Years →									
	Rates ¢/Lb[1]			Weight (lb)	Cost ($)	Weight (lb)	Cost ($)	Weight (lb)	Cost ($)
	Z	C1	NP						
1. Reading Matter	4.0	2.3	2.4						

2. Advertising

Zone	Distance (Miles)								
1&2	50-125	6.0	3.6	4.4						
3	125-250	7.2	4.4	5.2						
4	250-600	9.6	5.9	6.9						
5	600-1000	11.9	7.4	8.6						
6	1000-1400	14.4	9.0	9.4						
7	1400-1850	15.3	9.5	9.5						
8	1850 & Up	17.8	11.1	9.7						
	Total Advertising:									

	Rates, ¢ Each								
	Z	C1	NP	# Pcs.	Cost $	# Pcs.	Cost $	# Pcs.	Cost $
3. Per-Piece Cost	0.2	0.1	0.04						
4. Minimum Total Costs	1.3	0.8	0.2						
5. Total Calculated Cost (1 + 2 + 3)									
6. Total Cost (Larger of 4 or 5)									

(1) Regular zone-rate publications (Z), classroom publication (C1), or non-profit publications (NP)

Worksheet, Parcel Post, Annual Cost

ALTERNATIVE PROCEDURES:

(a) Enter inputs required in Alternative (a) below:

- Weight per year to each distance
- Number of pieces per year to each distance.

(b) Enter inputs required in Alternative (b), next page

- Weight per piece
- No. of pieces per year to each distance

Alternative (a), Costs for Year _____

	Distance (Miles) →	< 50	50-125	125-250	250-600	600-1000	1000-1400	1400-1850	>1850	
	Postal Zone →	Local	1,2	3	4	5	6	7		Total
Costs For Weight	Wt./Year (lb)									
	Cost/Lb	$0.036	$0.067	$0.076	$0.078	$0.121	$0.150	$0.188	$0.203	
	Cost/Year*									
Per-Piece Costs	No. Pieces/Year									
	Cost/Piece	$0.55	$0.600	$0.680	$0.800	$0.850	$0.900	$0.950	$1.000	
	Cost/Year**									
									TOTAL:	

* Cost/year = (weight/year) (cost/lb)

** Cost/year = (no. pieces/year) (cost/piece)

Worksheet, Parcel Post, Annual Cost (Cont'd)

ALTERNATIVE PROCEDURES:

(b) Enter inputs required in Alternative (b), below:

- Weight per piece
- No. of pieces per year to each distance

Alternative (b), Costs for Year _____

Weight/ Piece (lb)	Distance (Miles) →	50	50-125	125-250	250-600	600-1000	1000-1400	1400-1850	1850	Total
	Postal Zone →	Local	1,2	3	4	5	6	7	8	
	No. Pieces/Year Cost/Piece*									
	No. Pieces/Year Cost/Piece									
	No. Pieces/Year Cost/Piece									
	No. Pieces/Year Cost/Piece									

* From Table 5-14 in Volume IV, Part 2, User's Manual.

TOTAL:

Summary, Annual Mailing Costs

Mail Class \ Year	Annual Costs, Dollars									
First Class[1]										
Air Mail[1]										
Priority Mail[2]										
Second Class[3]										
Parcel Post[4]										

(1) From the Worksheet, Page 8-10.

(2) From the Worksheet, Page 8-11.

(3) From the Worksheet, Page 8-13.

(4) From the Worksheet, Page 8-14.

Calculation of Aircraft Costs

INPUTS REQUIRED:

Payload Weight _____ lb.

Area of Observation (A) _____ mi^2.

Interval Between Observations (I) _____ days.

Width of Observation Strip (W) _____ mi.

Average Suitable Observation Time Per Day (H) _____ hrs/day.

Average Number of Days/Year Suitable for Observation (D) _____ days.

CALCULATIONS:

Aircraft Gross Weight = (4) (Payload Weight) = (4) (_____) = _____ lb.

Aircraft Speed, V, (from Figure 5-12)* V = _____ mi/hr.

Number of Aircraft Required, $N = \frac{(365)}{WVHID}$

$$N = \frac{(365)\ (\quad)}{(\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)} = \_\_\_\_\_$$

Investment Cost Per Aircraft (from Figure 5-11)* = $_____/aircraft.

Total Investment Cost for Aircraft = (N) (Cost/Aircraft) = $ _____.

Annual Cost = $\frac{(365)\ (A)\ (\text{Cost/Mi})}{WI}$

Obtain cost/mile from Figure 5-10*.

Annual Cost = $\frac{(365)\ (\quad)\ (\quad)}{(\quad)\ (\quad)}$ = $_____.

* In Volume IV, Part 2, User's Manual.

Aircraft Costs by Year

Input Required \ Years									
Observation Area Added (Mi^2)									
Total Area Observed (Mi^2)									
INVESTMENT(1) COSTS									
ANNUAL COSTS									

(1) Assume 12-year useful life and a residual value of 15 percent of investment. Enter residual value as a "negative investment" in the year after the last of use. For periods of use shorter than 12 years, residual value equals the initial investment times [1 - (0.85) (years used/12)].

9. WORKBOOK FORMS FOR COST EFFECTIVENESS CALCULATIONS

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Alternate System Comparisons for Constant Dollars

YEARS		SPACE SYSTEMS									Terrestrial System		
		System #1			System #2			System #3			System #1		
		NPV	Peak Funding	Revenue	NPV	Peak Funding	Revenue	NPV	Peak Funding	Revenue	NPV	Peak Funding	Revenue
19__													
19__													
19__													
19__													
19__													
19__													
19__													
19__													
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19__													
19__													
19__													
19__													
19__													
19__													
19__													
19__													
19__													
19__													
Total													

System Cash Flow Comparisons, Current Dollars

YEARS	SPACE SYSTEM (S)				TERRESTRIAL SYSTEM	
	System #1		System #2		System #1	
	Cost	Revenue	Cost	Revenue	Cost	Revenue
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
19___						
Total						